

REMARKS

The Office Action mailed November 14, 2007, has been received and reviewed. Claims 10 through 28, and 30 through 34 are currently pending in the application. Claims 10 through 28, and 30 through 34 stand rejected.

Claim 10 has been amended to recite “a contact opening extending through at least one dielectric layer to an exposed region of a metal-containing layer on a semiconductor substrate.” Support for this amendment is found in the as-filed specification at at least page 7, lines 20-23 and page 10, lines 1-3 and FIGs. 3, 7, and 9. Claim 10 has further been amended to recite “applying a solution consisting essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer.” Support for this amendment to claim 10 is found in the as-filed specification at at least page 8, lines 3-6 and FIGs. 2 and 8.

Claims 21 and 32 have each been amended to recite “cleaning the partial via having at least a portion of the barrier layer exposed with a phosphoric acid-containing solution.” Support for this amendment is found in the as-filed specification at at least page 7, lines 13-23 and FIGs. 1-3. Claims 21 and 32 have further been amended to recite “etching the barrier layer after the cleaning to form a full via, a bottom surface thereof defined by a surface of a metal-containing trace.” Support for this amendment is found in the as-filed specification at at least page 7, lines 20-23 and FIGs. 3 and 8.

Claim 33 has been amended to recite “removing a portion of the dielectric layer overlying the barrier layer to form a partial via exposing at least portion of the barrier layer.” Support for this amendment is found in the as-filed specification at at least page 9, lines 14-20 and FIGs. 4-6. To improve clarity and form, claim 33 has further been amended to recite “etching the barrier layer to expose a region of a metal-containing trace underlying the barrier layer after the cleaning to form a full via.”

Claim 34 has been amended to recite “cleaning the partial via with a solution comprising water and phosphoric acid at a ratio of about 20:1 by volume at a temperature of about 35°C.” Support for this amendment is found in the as-filed specification at at least page 8, lines 18-20.

Support for new claims 36 through 38 is found in the as-filed specification at at least page

7, lines 4-12 and page 8, lines 8-26. No new matter has been added.

Applicant has amended claims 10, 21, 32 through 34, and respectfully requests reconsideration of the application as amended herein.

35 U.S.C. § 102(b) Anticipation Rejections

Anticipation Rejection Based on U.S. Patent No. 4,495,026 to Herberg

Claim 10 stands rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,495,026 to Herberg (“Herberg”). Applicant respectfully traverses this rejection, as hereinafter set forth.

A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Brothers v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). The identical invention must be shown in as complete detail as is contained in the claim. *Richardson v. Suzuki Motor Co.*, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989).

Herberg describes a method for manufacturing metallized semiconductor components. Herberg at the Abstract. An aluminum layer 2, a silver layer 3 and another aluminum layer 4 are applied over a substrate 1. *Id.*, col. 3, lines 1-8; FIG. 1. A layer 5 of negative acting photoresist and a layer 6 of positive acting photoresist are applied over the aluminum layer 4. *Id.*, col. 3, lines 9-16; FIG. 2. An etching agent, such as hot phosphoric acid, is used to remove the aluminum layer 4. *Id.*, col. 3, lines 18-25; FIGs. 3 and 4. The silver layer 3 is removed using an etching agent such as nitric acid. *Id.*, col. 3, lines 26-28; FIGs. 4-5.

Independent claim 10, as amended herein, recites “[a] method of removing oxide polymer and metal polymer from a contact opening extending through at least one dielectric layer to an exposed region of a metal-containing layer on a semiconductor substrate, the method comprising applying a solution consisting essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer followed by a phosphoric acid solution dip.”

Applicant respectfully submits that Herberg does not anticipate independent claim 4 because Herberg fails to describe, either expressly or inherently, “applying a solution consisting

essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer.” Rather, Herberg describes removing a silver layer 3 exposed through photoresist layers 5 and 6 by treating the silver layer 3 with nitric acid.

Because Herberg describes removing a metal-containing layer using nitric acid, Herberg does not expressly or inherently describe each and every element of amended independent claim 10.

As such, the anticipation rejection of claim 10 under 35 U.S.C. § 102(b) should be withdrawn.

Anticipation Rejection Based on U.S. Patent No. 4,417,385 to Temple

Claim 10 stands rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,417,385 to Temple (“Temple”). Applicant respectfully traverses this rejection, as hereinafter set forth.

Temple discloses processes for manufacturing insulated-gate semiconductor devices requiring a minimal number of photolithographic masking steps. Temple, col. 3, lines 20-24. The method includes performing an isotropic etch using a liquid mixture of hydrogen fluoride and nitric acid diluted with water to form channels through a nitride layer 90, a conductive gate layer 82 and a polysilicon gate layer 80. *Id.*, at col. 12, lines 43-67 through col. 13, lines 1-2.

Applicant respectfully submits that Temple does not anticipate independent claim 10 because Temple fails to describe, either expressly or inherently, “applying a solution consisting essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer.” Rather, Temple describes applying an etchant that includes a liquid mixture of hydrogen fluoride and nitric acid diluted with water to remove the exposed portion of the conductive gate layer 82. The Examiner has asserted that the conductive gate layer 82 is analogous to the “metal-containing layer” of claim 10. *See* Office Action or November 14, 2007, at page 2. Because the conductive gate layer 82 is removed during the etching process, Temple does not expressly or inherently describe a method that includes applying a solution including a nitric acid solution without substantially removing the exposed region of a metal-containing layer.

Since Temple does not expressly or inherently describe each and every element of amended independent claim 10, the anticipation rejection of claim 10 under 35 U.S.C. § 102(b) should be withdrawn.

35 U.S.C. § 103(a) Obviousness Rejections

Obviousness Rejection Based on U.S. Patent No. 3,635,774 to Ohta in View of U.S. Patent No. 4,900,695 to Takahashi et al.

Claims 10 through 14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 3,635,774 to Ohta (“Ohta”) in view of U.S. Patent No. 4,900,695 to Takahashi et al. (“Takahashi”). Applicant respectfully traverses this rejection, as hereinafter set forth.

To establish a *prima facie* case of obviousness the prior art reference (or references when combined) must teach or suggest all the claim limitations. *In re Royka*, 490 F.2d 981, 985 (CCPA 1974); *see also* MPEP § 2143.03. Additionally, the Examiner must determine whether there is “an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR Int’l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1740-1741, 167 L.Ed.2d 705, 75 USLW 4289, 82 U.S.P.Q.2d 1385 (2007). Further, rejections on obviousness grounds “cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *Id* at 1741, quoting *In re Kahn*, 441, F.3d 977, 988 (Fed. Cir. 2006). Finally, to establish a *prima facie* case of obviousness there must be a reasonable expectation of success. *In re Merck & Co., Inc.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986). Furthermore, the reason that would have prompted the combination and the reasonable expectation of success must be found in the prior art, common knowledge, or the nature of the problem itself, and not based on the Applicant’s disclosure. *DyStar Textilfarben GmbH & Co. Deutschland KG v. C. H. Patrick Co.*, 464 F.3d 1356, 1367 (Fed. Cir. 2006); MPEP § 2144. Underlying the obvious determination is the fact that statutorily prohibited hindsight cannot be used. *KSR*, 127 S.Ct. at 1742; *DyStar*, 464 F.3d at 1367.

A *prima facie* case of obviousness under 35 U.S.C. § 103(a) has not be established against any of claims 10 through 14 because the applied references themselves or the inferences and creative steps that a person of ordinary skill in the art would have employed at the time of the

invention would not have taught or suggested the claim limitations. Additionally, the Examiner has not provided a reason that would have prompted a person of ordinary skill in the relevant field to combine the applied references in the manner asserted.

Ohta teaches a method of manufacturing a semiconductor device by selectively etching a passivation film. Ohta, col. 1, lines 3-6. A silicon substrate 12 is covered with a silicon oxide film 13, a glass layer 14, a silicon nitride film 15 and a silicon dioxide film 16. *Id.*, col. 2, lines 19-25. A photoresist film 16 is patterned to expose a region of the underlying silicon dioxide film 16 through a hole 18. *Id.*, col. 2, lines 49-51. The silicon dioxide film 16 exposed through the hole 18 is removed using an etchant including hydrofluoric acid, such as a hydrofluoric acid/nitric acid system. *Id.*, col. 2, lines 19-25. The photoresist film 16 is removed and a phosphoric acid dip is used to remove a region of the silicon nitride film 15 exposed through the silicon dioxide film 16. *Id.*, col. 2, lines 60-65.

Takahashi teaches a semiconductor integrated circuit device and process of producing the same. Takahashi at the Abstract. The semiconductor integrated circuit device includes an insulating film 2 formed on the surface of a semiconductor substrate 1 and having aluminum wirings 3a and 3b formed thereon. *Id.*, col. 4, lines 46-65. Another insulating film 4 overlies wirings 3a and 3b and includes second-level aluminum wirings 5a and 5b formed thereon. *Id.* An insulating film 6 formed over the second-level wirings 5a and 5b. *Id.*

Applicant respectfully submits that the applied references do not teach or suggest all of the limitations of amended independent claim 10 because neither Ohta nor Takahashi, alone or in combination, teaches or suggests the limitation of “applying a solution consisting essentially of a nitric acid solution substantially on the contact opening” wherein the “contact opening [extends] through at least one dielectric layer to an exposed region of a metal-containing layer on a semiconductor substrate.” Rather, Ohta teaches subjecting a region of a silicon dioxide film 16 to an etchant including hydrofluoric acid and nitric acid to expose an underlying region of a silicon nitride film 15. *See* Ohta, col. 2, lines 52-59. Referring to FIG. 2d of Ohta, the hole 18 in the photoresist 17 through which the etchant is applied does not extend to a metal-containing layer on a semiconductor substrate. *See* Ohta at FIG. 2d. Takahashi teaches contact holes 7a and 7b that extend through an insulating film 6, wirings 5a and 5b and insulating film 4 to wirings 3a

and 3b. However, Takahashi does not teach applying a solution that includes a nitric acid on the contact holes 7a and 7b. Thus, Takahashi does not cure the deficiencies of Ohta.

The Examiner asserts that “it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a metal-containing layer underlying the dielectric on the semiconductor structure in order to form electrical connections.” Office Action at page 4. Takahashi teaches that wirings 3a and 3b are located beneath insulating films 4 and 6 and wirings 5a and 5b. Therefore, assuming *arguendo* that one of ordinary skill in the art would have been motivated to combine the wirings 3a and 3b of Takahashi with the semiconductor structure of Ohta (which Applicant does not concede), the wirings 3a and 3b would not be exposed when the etchant including hydrofluoric acid and nitric acid was applied to the semiconductor structure. As previously discussed, Ohta teaches a method that includes applying the hydrofluoric acid/nitric acid etchant to remove silicon dioxide film 16 from an upper layer of the semiconductor device. Because Ohta teaches that the purpose of applying the etchant including hydrofluoric acid and nitric acid is to remove silicon dioxide film 16, it is unclear why one of ordinary skill would be motivated to apply the hydrofluoric acid/nitric acid etchant to wirings 3a and 3b.

Because the applied references themselves or the inferences and creative steps that a person of ordinary skill in the art would have employed at the time of the invention would not have taught or suggested the limitations of amended independent claim 10 and there is no reason in the applied references, common knowledge, or the nature of the problem itself that would have prompted a person of ordinary skill in the art to combine the applied references in the asserted manner, it is respectfully submitted that a *prima facie* case of obviousness cannot be established against claim 21.

Each of claims 11 through 14 is allowable, *inter alia*, as depending from an allowable base claim.

Therefore, withdrawal of the 35 U.S.C. § 103(a) rejections of claims 10 through 14 is respectfully solicited, as is the allowance of each of these claims.

Obviousness Rejection Based on Herberg

Claims 11 through 17 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Herberg. Applicant respectfully traverses this rejection, as hereinafter set forth.

Claims 11 through 17 are each allowable, *inter alia*, as depending from an allowable base claim.

Obviousness Rejection Based on Temple

Claims 11 through 14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Temple. Applicant respectfully traverses this rejection, as hereinafter set forth.

Claims 11 through 14 are each allowable, *inter alia*, as depending from an allowable base claim.

Obviousness Rejection Based on Temple in view of U.S. Patent No. 3,867,218 to Henry

Claims 15 through 20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Temple in view of U.S. Patent No. 3,867,218 to Henry (“Henry”). Applicant respectfully traverses this rejection, as hereinafter set forth.

The teachings of Temple are as described above.

Henry teaches an etch bath including hydrofluoric acid, ammonium fluoride, phosphoric acid and water for local etching of silicon nitride. Henry, col. 2, lines 30-36.

Temple does not teach or suggest the limitation of “applying a solution consisting essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer” for the reasons discussed above in the respective anticipation rejections. Henry teaches selectively etching silicon nitride using an etch bath including hydrofluoric acid, ammonium fluoride, phosphoric acid and water. Thus, Henry does not cure the deficiencies of Temple.

As such, each of claims 15 through 20 are allowable, *inter alia*, as depending from an allowable base claim.

Applicant, therefore, respectfully requests that the rejections of claims 15 through 20 under 35 U.S.C. § 103(a) be withdrawn, and that each of these claim be allowed.

Obviousness Rejection Based on Ohta in view of Takahashi et al. and further in view of Henry

Claims 15 through 20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Ohta in view of Takahashi as applied to claim 10 above, and further in view of Henry. Applicant respectfully traverses this rejection, as hereinafter set forth.

The teachings of Ohta, Takahashi and Henry are as described above.

The Examiner relies on Henry as teaching using a phosphoric acid containing solution for etching silicon nitride with 36-34 volumes water and 1-10 volumes of phosphoric acid. Office Action at p. 9. However, claims 15 through 20 each depend from claim 10 and, therefore, include all of the limitations of claim 10. As such, claims 15 through 20 include the limitation of “applying a solution consisting essentially of a nitric acid solution on the contact opening without substantially removing the exposed region of the metal-containing layer” wherein the “contact opening [extends] through at least one dielectric layer to an exposed region of a metal-containing layer on a semiconductor substrate.” Ohta and Takahashi, alone or in combination, do not teach or suggest this limitation for the reasons previously discussed. Henry also fails to teach or suggest this limitation. Therefore, claims 15 through 20 are allowable at least by virtue of their dependency from claim 10.

Applicant, therefore, respectfully requests that the rejection of claims 15 through 20 under 35 U.S.C. § 103(a) be withdrawn, and that this claim be allowed.

Obviousness Rejection Based on WO 97/03469 to Krautschneider, referring to the English equivalent U.S. Patent 5,943,572 to Krautschneider, in view of U.S. Patent No. 5,511,020 to Hu et al. and further in view of Henry

Claims 21, 26 through 28, 30 and 31 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Krautschneider (WO 97/03469), referring to the English equivalent U.S. Patent 5,943,572 to Krautschneider (“Krautschneider”), in view of U.S. Patent No. 5,511,020 to Hu et al. (“Hu”) and further in view of Henry. Applicant respectfully traverses this rejection, as hereinafter set forth.

Independent claim 21, as amended herein, recites “[a] method of fabricating a via in a dielectric layer and an underlying barrier layer for a semiconductor device, comprising: forming a partial via in the dielectric layer to expose at least portion of the barrier layer; cleaning the partial via having at least a portion of the barrier layer exposed with a phosphoric acid-containing solution including a fluorine-containing component; etching the barrier layer after the cleaning to form a full via, a bottom surface thereof defined by a surface of a metal-containing trace; and applying a nitric acid-containing solution to the full via.”

A *prima facie* case of obviousness under 35 U.S.C. § 103(a) has not be established against amended independent claim 21 because the applied references themselves or the inferences and creative steps that a person of ordinary skill in the art would have employed at the time of the invention would not have taught or suggested the claim limitations.

Krautschneider teaches an electrically writable and erasable read-only memory cell arrangement. Krautschneider, col. 1, lines 54-55. Krautschneider teaches a device that includes trenches 4 in a doped trough 2 of a substrate 1. *Id.*, col. 6, lines 4-8. A dielectric layer 5 and a polysilicon layer 6 are formed over the surfaces of the device. *Id.*, col. 6, lines 17-28. Silicon nitride spacers 7 cover the polysilicon layer 6 on the sides of the trenches 4 and silicon dioxide structures 8 cover the polysilicon layer 6 on the bottom of the trenches 4. *Id.*, col. 6, lines 36-54. The silicon nitride spacers 7 are removed using hot phosphoric acid. *Id.*, col. 6, lines 55-57. Exposed regions of polysilicon layer 6 are etched with hydrofluoric acid/nitric acid using the silicon dioxide structure 8 as an etch mask. *Id.*, col. 6, lines 61-65.

Hu teaches a metal or a metal silicide as materials used for floating gates 106 in a PNVM cell 100. Hu, col. 4, lines 2-4.

The teachings of Henry are as summarized above.

The applied references do not teach or suggest all of the limitations of claim 21 because the applied references, alone or in combination, do not teach or suggest “cleaning the partial via having at least a portion of the barrier layer exposed with a phosphoric acid-containing solution including a fluorine-containing component.” Rather, Krautschneider teaches applying hot phosphoric acid to remove silicon nitride spacers 7 with respect to silicon oxide structures 8. The Examiner asserts that polysilicon layer 6 of Krautschneider functions as a barrier layer. *See*

Office Action at page 10. Referring to FIG. 2 of Krautschneider, the polysilicon layer 6 within the trenches 4 is covered by silicon nitride spacers 7 and silicon dioxide spacers 8 when the hot phosphoric acid is applied. As such, the “barrier layer” (*i.e.*, polysilicon layer 6) is not exposed during treatment with the hot phosphoric acid. The Examiner relies on Hu as teaching polysilicon, silicide and metals as floating gate electrodes in memory cells and on Henry as teaching a phosphoric acid solution for etching silicon nitride. *See* Office Action at pages 11 and 12. Thus, neither Hu nor Henry cures the deficiencies of Krautschneider.

Moreover, the applied references, alone or in combination, do not teach or suggest the limitation of “etching the barrier layer after the cleaning to form a full via, a bottom surface thereof defined by a surface of a metal-containing trace,” as recited in amended independent claim 21. Instead, Krautschneider teaches etching exposed portions of the polysilicon layer 6 to form polysilicon structures 6' within the trenches 4. As shown in FIG. 3 of Krautschneider, the polysilicon structures 6' are located within the trenches 4, but do not define the bottom surfaces thereof. As best understood by Applicant, the Examiner asserts that, based on the teachings of Hu, one of ordinary skill in the art would have been motivated to use a metal as the polysilicon structure 6' in Krautschneider. *See* Office Action at page 11. However, the polysilicon structure 6' of Krautschneider does not define the bottom of the trenches 4. Thus, regardless of what material one of ordinary skill in the art would have been motivated to use, the bottom of the trenches 4 of Krautschneider would not be defined by a surface of metal-containing trace. Henry does not teach or suggest the above-mentioned limitation of amended independent claim 21 and, thus, cannot cure the deficiencies of Krautschneider and Hu.

Because the applied references themselves or the inferences and creative steps that a person of ordinary skill in the art would have employed at the time of the invention would not have taught or suggested the limitations of amended independent claim 21, it is respectfully submitted that a *prima facie* case of obviousness cannot be established against claim 21.

Claims 26 through 28, 30, and 31 are each allowable, *inter alia*, as depending from an allowable base claim.

As such, withdrawal of the 35 U.S.C. § 103(a) obviousness rejections of claims 21, 26 through 28, 30, and 31 is respectfully solicited, as is allowance of each of these claims.

Obviousness Rejection Based on Krautschneider, in view of Hu and further in view of U.S. Patent 5,622,787 to Sakata

Claim 32 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Krautschneider, in view of Hu and further in view of U.S. Patent No. 5,511,020 to Sakata (“Sakata”). Applicant respectfully traverses this rejection, as hereinafter set forth.

A prima facie case of obviousness under 35 U.S.C. § 103(a) has not be established against amended independent claim 32 because the applied references themselves or the inferences and creative steps that a person of ordinary skill in the art would have employed at the time of the invention would not have taught or suggested the claim limitations. Additionally, the Examiner has not provided a reason that would have prompted a person of ordinary skill in the relevant field to combine the applied references in the manner asserted, and Sakata teaches away from Krautschneider.

The teachings of Krautschneider and Hu are previously discussed.

Sakata teaches a method of manufacturing a mask for use in patterning a semiconductor device. Sakata, col. 1, lines 9-12. Sakata teaches removing a portion of monocrystalline silicon 2 and a silicon oxide film 5 to form the mask 10. *Id.*, col. 7, lines 42-45. The monocrystalline silicon 2 and silicon oxide film 5 are dissolved using an etchant including 70% nitric acid and 50% hydrofluoric acid mixed in a volume ratio of 10:1. *Id.*, col. 7, lines 45-50.

Independent claim 32, as amended herein, recites “[a] method of fabricating a via in a dielectric layer and an underlying barrier layer for a semiconductor device, comprising: forming a partial via in the dielectric layer to expose at least portion of the barrier layer; cleaning the partial via having at least a portion of the barrier layer exposed with a phosphoric acid-containing solution; etching the barrier layer after the cleaning to form a full via, a bottom surface thereof defined by a surface of a metal-containing trace; and applying a nitric acid-containing solution a concentration of between about 50% and 100% by weight to the full via.”

The applied references do not teach or suggest all of the limitations of claim 32 because the applied references, alone or in combination, do not teach or suggest “cleaning the partial via having at least a portion of the barrier layer exposed with a phosphoric acid-containing solution

including a fluorine-containing component.” Specifically, Krautschneider teaches removing silicon nitride spacers 7 with respect to silicon dioxide structures 8 using hot phosphoric acid. Because the polysilicon layer 6 of Krautschneider is covered by silicon nitride spacers 7 and silicon dioxide structures 8 during etching with hot phosphoric acid, the polysilicon layer 6 is not exposed during treatment with the hot phosphoric acid. The Examiner relies on Hu as teaching polysilicon, silicide and metals as floating gate electrodes in memory cells and on Sakata as teaching as teaching an etchant for removing monocrystalline silicon 2 and silicon dioxide including 70% nitric acid. *See* Office Action at pages 11 and 12. Thus, neither Hu nor Sakata cures the deficiencies of Krautschneider.

The applied references, alone or in combination, also do not teach or suggest the limitation of “etching the barrier layer after the cleaning to form a full via, a bottom surface thereof defined by a surface of a metal-containing trace,” as recited in amended independent claim 32. Rather, exposed portions of the polysilicon layer 6 of Krautschneider are removed using an etchant including hydrofluoric acid and nitric acid to form polysilicon structures 6’ within the trenches 4. As shown in FIG. 3 of Krautschneider, the polysilicon structures 6’ overlies the bottom surfaces of the trenches 4 and, thus, cannot define the bottom surfaces of the trenches 4. The Examiner asserts that, based on the teachings of Hu, one of ordinary skill in the art would have been motivated to use a metal as the polysilicon structure 6’ in Krautschneider. *See* Office Action at page 11. Thus, regardless of what material one of ordinary skill in the art would have been motivated to use, the bottom of the trenches 4 of Krautschneider would not be defined by a surface of a metal-containing trace. Sakata does not teach or suggest the above-mentioned limitation of amended independent claim 32 and, thus, cannot cure the deficiencies of Krautschneider and Hu.

It is further submitted that, without the benefit of hindsight, there is no reason in the applied references, common knowledge, or the nature of the problem itself that would have prompted a person of ordinary skill in the art to combine Krautschneider, Hu and Sakata in the asserted manner. Applicant notes “the corollary principle that when the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious.” *KSR*, 127 S.Ct. at 1740. The Examiner states that “it would

have been obvious to one of ordinary skill in the art at the time the invention was made form the HF-nitric acid solution of Krautschneider between 50-100% to perform a complete dissolution of the silicon oxide film.” Office Action at page 14. However, Krautschneider teaches using an etchant including hydrofluoric acid and nitric acid to remove silicon nitride spacers 7 without removing silicon oxide structures 8. Because Sataka teaches the mixture of hydrofluoric acid and nitric acid to dissolve silicon oxide, Sakata actually teaches away from the combination with Krautschneider.

Since the applied references, alone or in combination, do not teach or suggest all of the claim limitations and there is no objective reason that would have prompted combination of the references, it is respectfully submitted that Krautschneider, Hu and Sakata do not support a *prima facie* case of obviousness of claim 32.

Therefore, withdrawal of the 35 U.S.C. § 103(a) rejection of claim 32 is respectfully solicited, as is the allowance of this claim.

Obviousness Rejection Based on Krautschneider, in view of Hu and further in view of Henry

Claims 33 and 34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Krautschneider, in view of Hu and further in view of Henry. Applicant respectfully traverses this rejection, as hereinafter set forth.

The teachings of Krautschneider, Hu and Henry are as previously discussed.

Independent claim 33, as amended herein, recites “[a] method of fabricating a via in a dielectric layer and a barrier layer for a semiconductor device, comprising: removing a portion of the dielectric layer overlying the barrier layer to form a partial via exposing at least portion of the barrier layer; cleaning the partial via with a phosphoric acid-containing solution at a concentration of between about 200 volumes of water to about 1 volume of phosphoric acid and about 1 volume of water to about 1 volume of phosphoric acid; etching the barrier layer to expose a region of a metal-containing trace underlying the barrier layer after the cleaning to form a full via; and applying a nitric acid-containing solution to the full via.”

The applied references do not teach or suggest all of the limitations of claim 33 because the applied references, alone or in combination, do not teach or suggest the limitation of

“removing a portion of the dielectric layer overlying the barrier layer to form a partial via exposing at least portion of the barrier layer.” Rather, Krautschneider teaches trenches 4 formed in a substrate 1 having a polysilicon layer 6, silicon nitride spacers 7 and silicon dioxide structures 8 formed thereover. Although Krautschneider teaches silicon dioxide spacers 7 and silicon dioxide structures 8 used to facilitate etching, Krautschneider does not teach a barrier layer underlying a dielectric layer that is removed to form the trenches 4 in the substrate 1. Hu teaches that a metal or a metal silicide is useful as a floating gate and Henry teaches an etchant for removing silicon nitride. Thus, Hu and Henry cannot cure the deficiencies of Krautschneider.

It is further submitted that Krautschneider, Hu and Henry, alone or in combination, do not teach or suggest the limitation of “etching the barrier layer to expose a region of a metal-containing trace underlying the barrier layer after the cleaning to form a full via” wherein “the dielectric layer [overlies] the barrier layer,” as recited in amended independent claim 33. Rather, Krautschneider teaches etching a polysilicon layer 6 using silicon dioxide structures 8 as an etch mask to form polysilicon structures 6'. The Examiner asserts that, based on the teachings of Hu, one of ordinary skill in the art would have been motivated to substitute a metal for the polysilicon layer 6 used to form a floating gate. *See* Office Action at page 11. Regardless, the polysilicon layer 6 of Krautschneider underlies a silicon dioxide structure 8 formed within trenches 4 in the substrate 1 and, thus, is not exposed by etching a barrier layer that underlies a dielectric layer. Hu and Henry do not cure the deficiencies of Krautschneider.

Independent claim 34, as amended herein, recites “[a] method of fabricating a via in a dielectric layer and an underlying barrier layer for a semiconductor device, comprising: forming a partial via in the dielectric layer to expose at least portion of the barrier layer; cleaning the partial via with a solution comprising water and phosphoric acid at a ratio of about 20:1 by volume at a temperature of about 35°C; etching the barrier layer after the cleaning to form a full via having a metal containing trace on a bottom surface thereof; and applying a nitric acid-containing solution to the full via.”

The applied references do not teach or suggest all of the limitations of claim 34 because the applied references, alone or in combination, do not teach or suggest the limitation of “cleaning the partial via with a solution comprising water and phosphoric acid at a ratio of about

20:1 by volume at a temperature of about 35°C.” Although Krautschneider discloses a hot phosphoric acid etch to remove silicon nitride spacers 7 from within trenches 4, Krautschneider does not disclose cleaning the trenches 4 using a solution that includes water and phosphoric acid in a 20:1 ratio by volume at a temperature of about 35°C. The Examiner acknowledges that Krautschneider does not teach or suggest the concentration of the solution or the temperature in which cleaning is conducted. *See* Office Action at page 16. As such, the Examiner relies on Henry as teaching a solution for etching silicon nitride at room temperature that includes 36-34 volumes water and 1-10 volumes phosphoric acid. *Id.* However, Henry does not teach or suggest etching silicon nitride using a solution that includes water and phosphoric acid in a 20:1 ratio by volume at a temperature of about 35°C and, thus, does not cure the deficiencies of Krautschneider.

Since the applied references, alone or in combination, do not teach or suggest all of the claim limitations, it is respectfully submitted that Krautschneider, Hu and Henry do not support a *prima facie* case of obviousness against either of claims 33 and 34.

As such, withdrawal of the 35 U.S.C. § 103(a) obviousness rejections of claims 33 and 34 is respectfully solicited, as is allowance of each of these claims.

New Claims

New claims 36-38 are presented herein. Applicant respectfully submits that these additional claims are allowable because none of the applied references relied upon by the Examiner describes, teaches, or suggests “[a] method of fabricating a via for a semiconductor device, the method comprising: removing at least a portion of a dielectric material exposed through an opening in an etch mask to form an oxide polymer layer on surfaces of the opening; removing a barrier layer underlying the opening to expose at least a portion of a metal-containing layer and to form a metal polymer layer over the surfaces of the opening; exposing the opening to a nitric acid-containing solution to substantially remove the metal polymer layer; and exposing the opening to a phosphoric acid-containing solution to substantially remove the oxide polymer layer.” Therefore, Applicant respectfully submits that new claims 36-38 are allowable over the applied references, and request that the Examiner allow these claims.

ENTRY OF AMENDMENTS

The amendments to claims 10, 21, 22, 32 through 34 and new claims 36-38 above should be entered by the Examiner because the amendments are supported by the as-filed specification and drawings and do not add any new matter to the application.

CONCLUSION

Claims 10 through 28, and 30 through 38 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain which might be resolved by a telephone conference, he is respectfully invited to contact Applicant's undersigned attorney.

Respectfully submitted,



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Date: February 14, 2008
JAW:TH/djp:ec
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